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Summary of Calibration Integration Factor (CIF) Corrections for the 1999 – 2002 Herring Acoustic Surveys in Northwest Atlantic Fisheries Organization (NAFO) Divisions 4VWX

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Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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ABSTRACT

In 2003, the Fisheries and Oceans Canada's Science Regional Advisory Process reviewed and approved the application of the Calibration Integration Factor (CIF) to acoustic biomass estimates for Northwest Atlantic Fisheries Organization divisions 4VWX herring. Unfortunately, inclusion of this approach required a significant amount of re-analysis of the original calibration and data files to apply the corrections. Survey biomass estimates with and without CIF were provided in the annual review, the former to move forward with the new approach, and the latter to make the current data comparable with historical estimates (1999-2002). This double reporting (with and without CIF) caused some confusion as to which series was being used to evaluate trends in biomass. In essence, the "without CIF" was considered valid for the period 1999 to 2009, while the "with CIF" was only available from 2003. This research document represents an overview of the process and procedures undertaken to update the acoustic survey biomass time series to include the CIF correction for the years 1999 to 2002. The re-analysis is now considered complete and the estimates of spawning stock biomass with CIF representative for the entire time series (1999 to present).

Résumé des corrections apportées au facteur d'intégration servant à l'étalonnage pour les relevés acoustiques sur le hareng effectués de 1999 à 2002 dans les divisions 4VWX de l'Organisation des pêches de l'Atlantique Nord-Ouest (OPANO)

RÉSUMÉ

En 2003, le processus de consultation régionale scientifique de Pêches et Océans Canada a examiné et approuvé l'application du facteur d'intégration servant à l'étalonnage aux estimations de la biomasse par relevé acoustique pour les divisions 4VWX de l'Organisation des pêches de l'Atlantique Nord-Ouest. Malheureusement, l'inclusion de cette approche a nécessité une nouvelle analyse importante des fichiers d'étalonnage et de données originaux afin d'appliquer les corrections. Les estimations de la biomasse par relevé avec et sans facteur d'intégration servant à l'étalonnage ont été fournies dans le cadre de l'examen annuel, les premières pour aller de l'avant avec la nouvelle approche, et les dernières pour pouvoir comparer les données actuelles aux estimations historiques (1999-2002). Cette double présentation d'estimations (avec et sans facteur d'intégration servant à l'étalonnage) a créé une certaine confusion concernant quelle série était utilisée pour évaluer les tendances de la biomasse. Essentiellement, les estimations « sans facteur d'intégration servant à l'étalonnage » ont été considérées comme valides pour la période de 1999 à 2009, tandis que les estimations « avec facteur d'intégration servant à l'étalonnage » n'étaient disponibles que depuis 2003. Ce document de recherche représente un aperçu du processus et des procédures visant la mise à jour de la série chronologique des estimations de la biomasse par relevé acoustique afin d'inclure la correction du facteur d'intégration servant à l'étalonnage pour les années 1999 à 2002. La nouvelle analyse est maintenant considérée comme terminée et les estimations de la biomasse du stock reproducteur avec le facteur d'intégration servant à l'étalonnage sont considérées comme représentatives pour toute la série chronologique (de 1999 à aujourd'hui).

INTRODUCTION

Acoustic surveys using commercial fishing vessels, first implemented in 1995, have played a key role in the assessment of the Northwest Organization Fisheries Organization (NAFO) Divisions 4VWX herring stock since 1999. Currently, the acoustic data collected by multiple vessels on several herring spawning grounds in the Maritimes Region provides the only index of abundance for the stock. Over the years, there have been a number of hardware, software and analytical changes that had an impact on the final biomass estimate. Around 2002, the Hydroacoustic Data Processing Software (HDPS) system from Femto Electronics Ltd. transitioned from analog (9001) to digital (DE9320) and, with it, the transformation of the software from "DOS" to "Windows". This was a major step forward, but the data files had a slightly different format and the calibration files for standardizing the system were different. Direct comparison of the old and new data was difficult without transforming the data to the DE9320 format and creating a new calibration file. Given that the results were comparable at the time for the original data, there was no need to undertake a comprehensive conversion/re-analysis of all surveys.

The 2004 Herring Regional Advisory Process (RAP) reviewed a presentation on the HDPS system and recommended a correction factor for the non-square waveform shape observed in a ball calibration be incorporated into the software (Melvin et al. 2003). The approach was also being used by several acoustic manufacturers when calibrating their echo sounders. The impact of including a Calibration Integration Factor (CIF) to estimate backscatter in the integration process varied depending on the vessel's acoustic hardware. In essence, a multiplier factor was applied to the standard calibration that typically ranged between 0.4 and 1.6, although most were close to 1.0 for the commercial vessels. An ideal square wave was equivalent to 1.0 and required no adjustment.

The RAP concluded that the inclusion of CIF provided a more accurate estimate of biomass and recommended that all future analyses utilize the CIF to calculate biomass (Melvin et al. 2003). However, because of the difficulties in applying the CIF to datasets prior to 2003, when comparing observations from year to year, it was recommended that the comparisons be made between biomass estimates that exclude the adjustment, until a time series has been established with the CIF included. Recalculation of spawning stock biomass (SSB) estimates for the years prior to 2003 (1999 to 2002) using the CIF has been an ongoing process, with only 2001-2002 completed up until last year. This report documents the procedures, results and the final outcome of the recalculation for all four years of biomass data that were affected by the inclusion of the CIF. Furthermore, it completes the acoustic survey corrections such that the entire time series of standardized surveys can be considered in the evaluation of stock status. Biomass estimates without the CIF should no longer be considered in monitoring/evaluating trends in abundance and will no longer be reported.

METHODS

OVERVIEW

A major problem with extending the CIF correction back to the period 1999-2002 was the calibration file associated with each vessel was not processed such that it contained the information necessary to calculate and apply the CIF. In 2008/09, all the original calibration files (raw calibration files) were re-analyzed for each vessel equipped with an HDPS and for each year to be reconstructed. This involved a varying number (4 - 8) of vessels depending upon the year. Once completed, the new calibrations could be used in the latest version of HDPS to estimate biomass "with" and "without" the CIF applied.

DATA QUALITY ISSUES

Acoustic analytical procedures and protocols have evolved over the past decade to improve our estimates of biomass. While the actual survey design and coverage area remains relatively unchanged (Melvin and Power 1999), a number of innovative approaches to editing and processing have been added to the HDPS software. Extracting transects from continuous data files, bottom detection algorithms, and the process for removing of non-herring targets from the echograms has changed over time with improvements to the software. Consequently, in order to incorporate the CIF into the analysis, it was necessary to go back to the original edited files and attempt to reproduce the biomass estimate using the software version of the time. This proved to be a more difficult task then expected for the initial two years of the time series. A number of physical moves, changes in personnel, and advancements in storage media have resulted in a few challenges in locating the original and edited data files, as well as editing notes for some surveys. In several surveys involving the portable acoustic system, there was a problem with the original data and the calibration file used in the analysis. For two surveys, the actual data analyzed could not be located. Overall, a vast majority of the results for each vessel and survey were in the original file format and software version and were reproducible. This provided confidence in the extension of the time series back to 1999, with the CIF applied.

The initial step in the analytical process was to reproduce the biomass estimates from original analysis in the software version where possible. This involved reverting to an old DOS version for surveys in 1999 to 2002 and in some cases the conversion of data file from DE9320 to J9001 format. Several methods were used to ensure the same data file was being used in the reconstruction as in the original analysis. These included length of the transect (m) and the number of pings. Once the original biomass was confirmed, the data were converted to DE9320 format, the new calibration file applied, and a revised estimate of biomass with CIF determined. When in doubt, a completely new analysis was undertaken and the new estimate used in the summary for both with and without CIF. For those cases with missing data files, or uncertainty about which calibration file was used we applied a mean CIF to the original results. For example, if a transect file for a specific vessel could not be located for validation, then the mean CIF for that vessel in the same year was applied to the original biomass estimate. In the case of the portable system where the results for a few transects in two surveys could not be reproduced, the ratio of "with" to "without CIF" was used as a multiplier to obtain the final SSB. In 1999, two of the 18 transects collected on July 25 had the multiplier applied to the original fish density estimates, otherwise all analysis was conducted in the usual manner.

RESULTS

Recalculation of SSB estimates for the earlier years from 1999 to 2002 using the CIF was completed for the 2001 and 2002 acoustic surveys in early 2008 and the results presented at the 2008 RAP meeting (Power and Melvin 2010). The results for these years have not changed from the original with CIF calculation, but are presented here for a matter of record. Unfortunately, this time-demanding re-evaluation could not be completed for 1999 and 2000 and was deferred until such time as funding could be obtained to re-analyze the acoustic data. Analysis of the 1999 and 2000 data was completed in 2012/13.

The initial requirement for the inclusion of CIF into the biomass estimate was to re-analyze the original calibration files with the Microsoft Windows© version (new in 2002) of the HDPS to estimate the calibration parameters. Two key parameters were required to convert the data files from the old to the new format and apply the CIF. The conversion factor was used by the HDPS to convert the original files from the J9001 to DE9320 format, or vice versa. This vessel specific factor varied from 108 to 145 (Table 1). The integration factor, associated with each vessel's calibration, necessary to convert biomass estimates from without CIF to with CIF are summarized by year and vessel and range from 0.465 for the portable system in 2000 to 0.925

for the purse seiner *Lady Melissa* in 2001. As a general rule, for most vessels the inverse of the integration factor is an estimate of the software internal multiplier for application of the CIF to the output results, although for a few vessels it is considered a direct multiplication. The largest CIF multiplier was found for the portable system in 2000 and 2001. Table 1 summarizes the standard calibration parameters for all survey vessels during the period 1999 to 2002.

Individual transects from all vessels for all surveys were re-examined under the quality control process. When inconsistencies were observed between the original (without CIF) and the re-analysis (without CIF), the re-analysis of the raw acoustic data was considered valid, although significant differences were observed in very few cases (<1% of transects). This process resulted in three estimates of SSB for each survey.; the original biomass, the new biomass (without CIF) and the new biomass (with CIF). The three biomass estimates for Scots Bay, Trinity Ledge, and German Bank are summarized by spawning ground, survey and year in tables 2-5. In 1999, the greatest difference between the original SSB and the re-analyzed estimate without CIF occurred on German Bank where there was an overall reduction in two of the three acoustic surveys of 37 and 17% (Table 2). The source of this change is unknown, but likely related to differences in bottom interpretation when fish were very near the bottom. Scots Bay and Trinity Ledge survey estimates remained essentially unchanged. The ratio of CIF and without CIF serves to illustrate the relative change in the biomass estimates resulting from the application of the CIF approach (Table 1). The ratio varies (1.09 to 1.37) from survey to survey and is a function of the vessels involved in the survey. Comparison of the original SSB with the total SSB (with CIF) resulted in increases ranging from 4-11% for specific spawning grounds. The total SSB (with CIF) for Scots Bay and German Bank combined increased from 501,795 to 541,268t (8%) due to the inclusion of the CIF. The addition of Trinity Ledge to the total did not result in a change in the percent increase (Table 1).

The 2000 surveys illustrate that the application of CIF does not always increase the biomass. Scots Bay SSB increased slightly from the original analysis to the re-analysis in two of the three surveys, and overall by about 2%. However, significant differences in the total SSB for the spawning ground were observed for the with CIF estimates. The SSB increased from the original estimate of 106,316t to 185,498t (Table 3) representing a 75% increase. This is largely due to a single system with a relatively high CIF multiplier. Similar observations occurred for German Bank where there was a decrease in the SSB from the original to the re-analyzed, and a subsequent increase from the re-analyzed SSB (without CIF) to the SSB with CIF. Overall, the biomass increased from 462,688t to 616,328t for Scots Bay and German Bank combined. Although the SSB for Trinity Ledge more than doubled in 2000, it resulted in virtually no increase in the percent difference due to the small observed biomass (Table 3).

The 2001 acoustic biomass estimates with CIF applied was first reported to the RAP in 2009 and has been reported in all biomass estimates since. Again there were relatively small biomass differences between the original SSB (without CIF) and the revised SSB (without CIF) used for quality control and repeatability (Table 4). For Scots Bay and German Bank SSB combined, the biomass increased from 354,393 to 358,188t (1.0%). Significant increases were observed, however, when the CIF was applied to the re-analyzed data with CIF, the percent changes for Scots Bay, Trinity Ledge, and German Bank were 31.2, -0.5, and 32.9%, respectively. Overall, this represents an increase from 373,013t to 488,089t for the three spawning areas combined (Table 4). For Scots Bay and German Bank, it represents approximately a 32% increase in the estimated SSB. The percent change for an individual survey is a function of the vessels involved in the survey.

The application of the CIF to the survey data from 2002 resulted in increases and decreases in the SSB for individual spawning grounds from those originally reported (Table 5). Re-analysis of the data resulted is a slight decrease in the SSB for all three spawning areas from the original estimate to the new estimated without CIF (Table 5). However, when the CIF was applied to the

Scots Bay and Trinity Ledge survey data, it resulted in a decrease in SSB of 4 and 11%, respectively, and an increase for German Bank of approximately 14% (Table 5). Overall, the combined Scots Bay and German Bank SSB for 2002 was 545,889t, with the CIF representing an increase of 11,820t or 2.2% from the original estimate (Table 5). The inclusion of Trinity Ledge into the total SSB decreased the total percent change by 3% or 10,177t from the original estimate of 542,165t.

Comparison of the original biomass estimates with the revised estimates (with CIF) show a general overall increase for the latter, however, the trends were generally consistent (Figure 3) with the previous analysis. In Scots Bay and Trinity Ledge, the original was higher than the with CIF for several of the earlier years in the time series, while German Bank was slightly higher for all years (Figure 3). The original and with CIF SSB estimates for the three spawning grounds are presented in Figure 4. Note that beyond 2009, the without CIF was no longer calculated or reported (Power et al. 2010).

The results of the re-analysis and the application of the CIF to other areas outside the three main spawning grounds are contained in tables 6 through 9. The areas for which re-analysis was conducted varied from year to year depending upon whether or not acoustic or mapping surveys were conducted. In 1999, a single survey at Eastern Passage was re-analyzed, while in 2000, only the October 1 acoustic survey was re-analyzed (tables 6 and 7). Changes in the biomass estimates from the original to with CIF were similar to main spawning grounds and ranged from an increase of 9% and 38% in 1999 and 2000, respectively. In 2001, acoustic data from Seal Island, Browns Bank, and Spectacle Buoy, as well as Little Hope, were re-examined and the CIF applied (Table 8). The SSB increased in five of the seven surveys, one remained unchanged, and one decreased slightly from the original to the with CIF (Table 8). The percent change ranged from 0 to 43% and depended upon the area and the vessel(s) used in the survey. In 2002, data from Little Hope and Eastern Passage were examined and CIF applied. At the former, a large number of small and independent aggregations of spawning herring were observed and surveyed on September 29th and October 8th. In all cases, the SSB decreased from the original estimate by 14% when the CIF was applied (Table 9). At Eastern Passage, the opposite occurred with an increase for all acoustic surveys from the original estimate. The percent increase ranged from 19 to 33% (Table 9).

DISCUSSION

In 2003, the RAP reviewed and approved the application of the CIF to acoustic biomass estimates. Unfortunately, this required a significant amount of re-analysis of the original calibration and data files to apply the CIF. To accommodate this recommendation at RAP, both biomass estimates with and without CIF were provided in the annual review, the former to move forward with the new approach, and the latter to make the current data comparable with historical estimates (1999-2002). This double reporting (with and without CIF) in the research document caused some confusion as to which series was being used to evaluate trends in biomass. In essence, the without CIF was considered valid for the period 1999 to 2009, while the with CIF was valid only from 2003 (Power et al. 2002, 2008).

Sufficient funds were found in 2008 to extend the analysis back two years. The results of this analysis were presented at the RAP in 2009 and the time series with CIF applied expanded to include 2001 and 2002. Given the length of the time series (nine years) it was also decided to exclude any reference to SSB without CIF from the research document (Power et al. 2012). Beginning in 2010, only the SSB with CIF applied would be presented to evaluate trends in the biomass. The intent was always, however, to extend the time series to include 1999 and 2000 when time and additional funds became available.

The results presented in this research document represent the extensive efforts of several individuals to track down original data files and analytical records used in the early years of

biomass estimates. Quality control protocols were established and for the vast majority of surveys, biomass estimates are comparable from J9001 to DE9320 data formats and DOS to Windows software. Where differences were observed the original data were re-analyzed using the latest software version and applying the CIF. In a few cases, significant differences were observed and the re-analyzed estimates of biomass were deemed to be valid for estimating spawning ground biomass for the year.

In summary, the data and results presented represent the best estimate of SSB, incorporating CIF for the acoustic surveys occurring between 1999 and 2002. Although some uncertainty associated with the portable system remains, further analyses are unlikely to resolve the few discrepancies. The estimates for 2001 and 2002 have been incorporated into the time series since 2009. It is recommended that the acoustic biomass time series for specific spawning areas be extended to include 1999 and 2000 results. Acoustic data without the CIF applied will no longer be reported for analysis using the HDPS acoustic software.

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TABLES

Table 1. Summary of vessel calibration parameters from 1999 to 2002. The CIF is listed under "Integration Factor. The conversion factor is the value necessary to convert from DE9320 file format to J9001 format. A "-", indicates no information.

Vessel Name	Port for install	Calibration Date	Freq. (kHz)	Linear Mean	Log Mean	Main Mode	Number Echoes	Variation	Integration Factor	Conversion Factor	Cal File name	Ball TS	Pulse Duration	EIB	Mean Depth	Mean Temp	Mean Salinity	Mean PH	For Data File Format
1999																			
Leroy & Barry	Museum,Hfx,NS	1-Jun-99	50	-41.00	-41.00	-41.00	1081	0.10 dB	0.795	135	L299_WIN.CAL	-41	1.0	-16.05	60	5	32	8	DE9320
Dual Venture	Karlsen,Hfx,NS	30-May-99	50	-41.02	-41.02	-41.00	1500	0.07 dB	0.643	108	D299_WIN.CAL	-41	0.8	-12.06	60	5	32	8	DE9320
Portable system	From1998	21-Oct-98	50	-41.00	-41.02	-41.50	96	0.48 dB	0.914	135	P298_WIN.CAL	-41	0.8	-16.05	60	5	32	8	DE9320
Secord	Yarmouth,NS	3-Jul-99	50	-40.99	-40.99	-41.00	1223	0.07 dB	0.822	135	S299_WIN.CAL	-41	1.0	-16.05	60	5	32	8	DE9320
Island Pride	Cape Sable,NS	22-May-99	50	-41.00	-41.00	-41.00	1381	0.15 dB	0.757	145	I099_WIN.CAL	-41	0.6	-12.53	30	5	32	8	DE9320
Margaret Elizebeth	Karlsen,Hfx,NS	7-May-99	50	-41.00	-41.00	-41.00	751	0.25 dB	0.834	140	M099_WIN.CAL	-41	1.0	-14.71	40	5	32	8	DE9320
2000																			
Leroy & Barry	Museum,Hfx,NS	8-Jun-00	50	-41.00	-41.00	-41.00	726	0.12 dB	0.874	135	L220_WIN.CAL	-41	1.0	-16.05	60	5	32	8	DE9320
Dual Venture	Digby,NS	29-Jul-00	50	-40.99	-41.00	-41.00	314	0.11 dB	0.685	108	D220_WIN.CAL	-41	0.8	-12.06	60	5	32	8	DE9320
Portable system	Halifax,BIO,NS	18-Oct-00	50	-41.00	-41.00	-41.00	353	0.26 dB	0.465	135	P200_WIN.CAL	-41	1.0	-16.05	60	5	32	8	DE9320
Secord	Museum,Hfx,NS	23-Jun-00	50	-41.00	-41.00	-41.00	724	0.08 dB	0.823	135	S220_WIN.CAL	-41	1.0	-16.05	60	5	32	8	DE9320
Island Pride	Cape Sable,NS	23-Jun-00	50	-41.00	-41.00	-41.00	498	0.12 dB	0.714	145	I020_WIN.CAL	-41	0.7	-11.44	60	5	32	8	DE9320
Margaret Elizebeth	Blacks Harbour,NB	21-Jul-00	50	-41.00	-41.00	-41.00	910	0.20 dB	0.877	140	M02_WIN.CAL0	-41	1.0	-14.71	40	5	32	8	DE9320
Attaboy	Yarmouth,NS	17-Sep-00	120	-39.51	-39.51	-39.50	1008	0.22 dB	0.727	135	A220_WIN.CAL	-39.5	1.0	-14.71	40	5	32	8	DE9320
2001																			
Leroy & Barry	Shelburne,NS	15-Jun-01	50	-41.00	-41.01	-41.00	147	.025 dB	0.811	135	L221_WIN.CAL	-41	1.0	-16.05	60	5	32	8	DE9320
Dual Venture	Museum,Hfx,NS	23-Jun-01	50	-41.02	-41.02	-41.00	1012	0.08 dB	0.673	108	D221_WIN.CAL	-41	0.8	-12.06	60	5	32	8	DE9320
Portable system	Halifax,BIO,NS	2-Oct-01	50	-41.01	-41.02	-41.00	688	0.16 dB	0.551	135	P201_WIN.CAL	-41	1.0	-16.05	60	5	32	8	DE9320
Secord	Pier26,Hfx,NS	27-Jun-01	50	-41.00	-41.01	-41.00	698	0.21 dB	0.810	135	S221_WIN.CAL	-41	1.0	-16.05	60	5	32	8	DE9320
Island Pride	Museum,Hfx,NS	27-Jun-01	50	-41.00	-41.00	-41.00	613	0.28 dB	0.633	135	I021_WIN.CAL	-41	0.7	-11.44	60	5	32	8	DE9320
Margaret Elizebeth	Blacks Harbour,NB	9-Jun-01	50	-41.01	-41.20	-41.00	169	0.31 dB	0.842	140	M02_WIN.CAL1	-41	1.0	-14.71	40	5	32	8	DE9320
Crystal K	OwlsHead,NS	24-Sep-01	120	-39.50	-39.50	-39.50	375	0.16 dB	0.781	135	C201_WIN.CAL	-39.5	1.0	-14.71	40	5	32	8	DE9320
Attaboy	Yarmouth,NS	14-Jun-01	120	-39.50	-39.50	-39.40	433	0.19 dB	0.699	135	a221_win.CAL	-39.5	1.0	-14.70	40	5	32	8	DE9320
2002																			
Leroy & Barry	Karlsen,Hfx,NS	14-Jun-02	50	-41.00	-41.01	-41.00	390	0.13 dB	0.880	-	L202_win.CAL	-41	1.0	-16.05	40	5	32	8	DE9320
Dual Venture	HalifaxPier24,NS	8-Jun-02	50	-41.00	-41.00	-41.00	285	0.23 dB	0.655	-	D202_WIN.CAL	-41	0.8	-12.06	40	5	32	8	DE9320
Lady Melissa	Karlsen,Hfx,NS	8-Jul-02	50	-41.00	-41.00	-41.00	1034	0.04 dB	0.925	-	P202_WIN.CAL	-41	1.0	-15.63	40	5	32	8	DE9320
Secord	Shelburne,NS	16-Jun-02	50	-41.00	-41.00	-41.00	574	0.11 dB	0.913	-	S202_WIN.CAL	-41	1.0	-16.05	40	5	32	8	DE9320
Island Pride	Pier24,Hfx	8-Jun-02	50	-41.00	-41.00	-41.00	303	0.13 dB	0.736	-	I202_WIN.CAL	-41	0.7	-11.44	60	5	32	8	DE9320
Margaret Elizebeth	Blacks Harbour,NB	21-Jul-02	50	-41.00	-41.00	-41.00	891	0.21 dB	0.919	-	M02_WIN.CAL2	-41	1.0	-14.71	40	5	32	8	DE9320
Crystal K	Jeddore,NS	4-Oct-02	120	-39.50	-39.53	-39.60	300	0.46 dB	0.696	-	K202_WIN.CAL	-39.5	1.0	-14.71	40	5	32	8	DE9320
Attaboy	Yarmouth,NS	12-Jun-02	120	-39.51	-39.51	-39.50	397	0.09 dB	0.701	-	A202_WIN.CAL	-39.5	1.0	-14.71	40	5	32	8	DE9320

Table 2. Summary of the 1999 original, re-analyzed (without CIF) and CIF SSB by survey for the three spawning grounds: Scots Bay, Trinity Ledge, and German Bank. A "-", indicates no information.

Location	Date	Area (km^2)	Weighted Sa (dB)/m^2	Density (kg/m^2)	Mean Length	Target Strength	Biomass (t)	Standard Error	New Biomass W/O CIF	New Biomass W/ CIF	Standard Error	Ratio CIF vs W/O CIF
Scots Bay												
Scheduled	25-Jul	312.31	-47.107	0.071	28.17	-35.65	22307	19630	22307	24335	21415	1.09
Fishing	08-Aug	5.22	-33.68	1.587	28.3	-35.7	8284	2360	7711	9380	2672	1.22
Scheduled	10-Aug	11.96	-39.665	0.401	28.3	-35.7	4800	859	4267.5	5191	929	1.22
Scheduled	20-Aug	1.35	-32.17	2.151	28.3	-35.7	10381	9758	10381	12194	11462	1.17
Scheduled	03-Sep	712	-	-	-	-	-	-	-	-	-	-
Sub-total							**40972**	-	**40399**	**45909**	-	-
German Bank												
Acoustic	27-Aug	474	-39.07	0.404	28.51	-35.74	191496	81263	120908	165085	70055	1.37
Acoustic	10-Sep	198	0.922	0.922	27.31	-35.49	182637	22497	182637	240453	29619	1.32
Acoustic	25-Sep	7.3	-25.164	11.313	28.34	-35.7	82790	36580	68301	85922	37964	1.26
Acoustic	02-Oct	302	-	-	-	-	-	-	-	-	-	-
Mapping	08-Oct	9.26	-	-	-	-	3900	-	3900	3900	-	-
Sub-total							**460823**	-	**375746**	**495360**	-	-
Trinity												
Acoustic	27-Aug	0.4	-29.113	4.663	28.83	-35.8	1875	-	1875	2051.2	-	1.09
Mapping	08-Aug	241	-	-	-	-	2010	-	2010	2010	-	-
Sub-total							**3885**	-	**3885**	**4061**	-	-
Total Scots Bay and German Bank							**501795**	-	**416145**	**541268**	-	-
Total Scots Bay German Bank and Trinity Ledge							**505680**	-	**420030**	**545330**	-	-

Table 3. Summary of the 2000 original, re-analyzed (without CIF) and CIF SSB by survey for the three spawning grounds: Scots Bay, Trinity Ledge, and German Bank. A "-", indicates no information.

Location	Date	Area (km^2)	Weighted Sa $(dB)/m^2$	Density (kg/m^2)	Mean Length	Target Strength	Biomass (t)	Standard Error	New Biomass W/O CIF	New Biomass W/ CIF	Standard Error	Ratio CIF vs W/O CIF
Scots Bay												
Acoustic	01-Aug	377.8	-45.231	0.1199	28.02	-35.65	45284	15,400	47,961	91816	31224	1.91
Acoustic	14-Aug	369	-46.523	0.0822	28.17	-35.68	30322	14,331	25,134	28999	13706	1.15
Acoustic	29-Aug	24.5	-34.809	1.2535	28.13	-35.79	30710	14,962	30,089	64683	31514	2.15
Sub-total							**106316**	-	**103184**	**185498**	-	-
German Bank												
Acoustic	29-Aug	366	-42.426	0.204	28.12	-35.77	74808	22338	68762	100250	29935	1.46
Acoustic	12-Sep	96	-32.401	1.269	28.37	-35.72	121783	32959	105385	132399	35832	1.26
Acoustic	27-Sep	338	-38.531	0.43	28.2	-35.68	145273	44331	51043	80923	24694	1.59
Fishing	14-Oct	2.7	-28.458	5.3731	28.63	-35.76	14508	1218	14509	20369	1710	1.40
Sub-total							**356372**	-	**239699**	**333940**	-	-
Trinity												
Acoustic	12-Sep	0.5	-34.567	1.24	-	-35.5	621	113	621	1336	243	2.15
Sub-total							**621**	-	**621**	**1336**	-	-
Total Scots Bay and German Bank							**462688**	-	**342883**	**519437**	-	-
Total Scots Bay, German Bank, and Trinity Ledge							**463309**	-	**343504**	**520773**	-	-

Table 4. Summary of the 2001 original, re-analyzed (without CIF) and CIF SSB by survey for the three spawning grounds: Scots Bay, Trinity Ledge, and German Bank. A "-", indicates no information.

Location	Date	Area (km^2)	Weighted Sa $(dB)/m^2$	Density (kg/m^2)	Mean Length	Target Strength	Biomass (t)	Standard Error	New Biomass W/O CIF	New Biomass W/ CIF	Standard Error	Ratio CIF vs W/O CIF
Scots Bay												
Acoustic	Jul 16	325	-41.86	0.2414	27.52	-35.69	78458	22594	78806	87205	25957.12	1.11
Acoustic	Jul 16	15.6	-38.21	0.5591	27.52	-35.69	8722	536	9166	11718	614	1.34
Acoustic	Jul 31	104	-38.459	0.464	26.25	-35.12	48256	9525	48231	67248	13747.17	1.39
Acoustic	Jul 31	166	-49.5	0.0365	26.25	-35.12	6061	6061	6055	12002	3310.813	1.98
Acoustic	Aug 16	250	-45.739	0.0896	26.22	-35.26	22401	22401	22434	37842	4157.233	1.69
Sub-total							**163898**	-	**164692**	**216016**	-	-
Trinity Ledge												
Acoustic	Aug-28	0.71	-27.229	7.657	27.44	-36.07	5437	2050	5437	5,437	-	1.00
Acoustic	Aug-28	0.02	-29.661	4.425	27.44	-36.07	885	350	885	885	-	1.00
Acoustic	Sep-11	1.53	-33.537	1.733	-	-35.96	3275	2599	3,303	3242	765.2	0.99
Fishing	Sep-26	1.3	-	4	-	-	5200	-	5200	5200	-	1.00
Sub-total							**14797**	-	**14825**	**14764**	-	-
German Bank												
Acoustic	Aug-27	120	-42.029	0.234	28.3	-35.71	28017	1083	27830	33,622	1151	1.20
Acoustic	Aug-27	80	-47.748	0.064	28.3	-35.71	5004	1561	5000	5537	1731	1.11
Acoustic	Sep-09	325	-45.751	0.096	27.55	-35.55	31026	1191	30955	36481	1386	1.18
Acoustic	Sep-13	200	-39.314	0.404	26.86	-35.38	80847	3659	80847	123436	5420	1.53
Acoustic	Oct-03	28	-33.209	1.623	26.57	-35.33	45600	14995	48864	58233	559	1.28
Sub-total							**190494**	-	**193496**	**257310**	-	-
Total Scots Bay and German Bank							**354392**	-	**358188**	**473326**	-	-
Total Scots Bay, German Bank, and Trinity Ledge							**369189**	-	**373013**	**488089**	-	-

Table 5. Summary of the 2002 original, re-analyzed (without CIF) and CIF SSB by survey for the three spawning grounds: Scots Bay, Trinity Ledge, and German Bank. A "-", indicates no information.

Location	Date	Area (km2)	Weighted Sa (dB)/m2	Density (kg/m2)	Mean Length	Target Strength	Biomass (t)	Standard Error	New Biomass W/O CIF	New Biomass W/ CIF	Standard Error	Ratio CIF vs W/O CIF
Scots Bay												
Survey	Jul-28	325	-44.74	0.127	27.87	-35.76	41211	6062	39672	38856	6071	0.94
Survey	Aug-11	400	-49.448	0.04	27.45	-35.42	15824	10231	15826	15047	9481	0.95
Survey	Aug-21	275	-40.765	0.29	27.32	-35.4	79938	17001	76685	72016	6430	0.90
Fishing	Sep-02	1.3	-30.902	2.709	26.42	-35.26	3522	886	3522	3346	88	0.95
Survey	Sep-02	195	-61.568	0.002	26.42	-35.26	453	243	453	453	-	1.00
Sub-total							**140948**	-	**136158**	**129718**	-	-
German Bank												
Fishing	Aug-11	31	-46.03	0.09	27.75	-35.65	2866	1083	2875	3843	2338	1.34
Survey	Aug-26	450	-41.51	0.26	28.04	-65.68	117673	18636	90402	114199	50198	0.97
Survey	Sep-10	375	-42.11	0.21	27.45	-35.37	79410	7274	79401	108837	2849	1.37
Fishing	Sep-19	35	-28.16	5.18	27.23	-35.28	181264	40070	181290	174042	40238	0.96
Fishing	Sep-29	0.35	-25.58	9.06	26.57	-35.15	3623	970	3634	4857	2591	1.34
Fishing	Oct-08	14	-37.6	0.58	26.57	-35.24	8285	2832	8213	10403	4998	1.26
Sub-total							**393121**	-	**365815**	**416181**	-	-
Trinity Ledge												
Acoustic	Sep-02	0.47	-27.36	7.244	n/a	-35.96	3405	357	3275	2903	648	0.00
Acoustic	Sep-08	0.35	-29.81	4.127	n/a	-35.96	2472	2050	-	-	-	-
Acoustic	Sep-13	0.6	-27.02	7.819	n/a	-35.96	4691	440	3993	3540	286	0.75
Sub-total							8096	-	7268	6443	-	-
Total Scots Bay and German Bank							**534069**	-	**501973**	**545899**	-	-
Total Scots Bay, German Bank and Trinity Ledge							**542165**	-	**509240**	**552342**	-	-

Table 6. Summary of the 1999 original, re-analyzed (without CIF) and CIF SSB by survey for Eastern Shore spawning grounds. A "-", indicates no information.

Location	Date	Area (km^2)	Weighted Sa (dB)/m^2	Density (kg/m^2)	Target Strength	Biomass (t)	Standard Error	New Biomass W/O CIF	New Biomass W/ CIF	Standard Error	Ratio CIF vs W/O CIF
Eastern Shore											
Mapping	02-Oct	-	-	-	-	20226	-	20226	20226	-	-
Acoustic	04-Oct	0.3	-23.589	15.527	-35.5	4658	3084	4658	5094.7	3373.125	1.09
Mapping	10-Oct	-	-	-	-	9500	-	9500	9500	-	-
Total						**34384**	-	**34384**	**34821**	-	-

Table 7. Summary of the 2000 original, re-analyzed (without CIF) and CIF SSB by survey for Little Hope spawning grounds. A "-", indicates no information.

Location	Date	Area (km^2)	Weighted Sa (dB)/m^2	Density (kg/m^2)	Target Strength	Biomass (t)	Standard Error	New Biomass W/O CIF	New Biomass W/ CIF	Standard Error	Ratio CIF vs W/O CIF
Little Hope											
Acoustic	01-Oct	1.61	-30.403	3.425	-36.19	5224	824	6080.5	8367.4	1320	1.38
Acoustic	02-Oct	0.03	-29.26	4.932	-36.19	148	-	-	-	-	-

Table 8. Summary of the 2001 original, re-analyzed (without CIF) and CIF SSB by survey for Little Hope, Seal Island, and Browns Bank. A "-", indicates no information.

Location	Date	Area (km^2)	Weighted Sa (dB)/m^2	Density (kg/ m^2)	Mean Length	Target Strength	Biomass (t)	Standard Error	New Biomass W/O CIF	New Biomass W/ CIF	Standard Error	Ratio CIF vs W/O CIF
Other Areas												
Seal Island	Sep-25	275	-54.768	0.012	37.5	-35.49	3248	529	-	3897	635.3	1.20
Browns Bank	Sep-25	400	-45.393	0.102	-	-35.5	40996	10791	40996	45095	11042.9	1.10
Browns Bank	Oct-10	9.6	-38.019	0.56	25.41	-35.02	4809	1875	-	-	-	-
Sub-total							**190494**	-	-	-	-	-
Spectacle Buoy												
Acoustic	Jun-28	0.17	-35.098	1.22	-	-35.96	207.3		-	296.4	114.6	1.43
Acoustic	Jun-14	0.17	-30.52	3.5	-	-35.96	594.9	80.12	-	850.7	-	1.43
Acoustic	Sep-23	7	-24.53	12.503	-	-35.5	87521		87518	87518	8180	1.00
Sub-total							**88323**	-	-	-	-	-
Little Hope												
Acoustic	Sep-19	2.3	-28.077	6.143	-	-35.96	14127	4473	14125	14460	652	1.02
Acoustic	Oct-07	1.68	-29.644	3.852	-	-35.96	7193	2230	6471	6471	2021	0.9
Sub-total							**21320**	-	**20596**	**20931**	-	-

Table 9. Summary of the 2002 original, re-analyzed (without CIF) and CIF SSB by survey for Eastern Shore and Little Hope spawning grounds. Note that several independent aggregations of herring were surveyed in 2002 at Little Hope on a given night. A "-", indicates no information.

Location	Date	Area (km^2)	Weighted Sa (dB)/m^2	Density (kg/m^2)	Target Strength	Biomass (t)	Standard Error	New Biomass W/O CIF	New Biomass W/ CIF	Standard Error	Ratio CIF vs W/O CIF
Little Hope											
Survey	Sep-23	22.86	-44.14	0.15	-35.96	3479	1057	3478	3083	4490	0.89
Fishing	Sep-24	0.77	-38.19	0.6	-35.96	461	321	461	409	284	0.89
Survey	Sep-26	0.42	-26.11	9.66	-35.96	4193	718	4048	3589	638	0.86
Survey	Sep-29	0.35	-39.36	0.46	-35.96	160	-	83	73	-	0.46
Survey	Sep-29	4.3	-34.72	1.33	-35.96	5723	4213	5708	5060	3734	0.88
Survey	Sep-29	1.3	-42.22	0.24	-35.96	308	-	308	273	-	0.89
Survey	Sep-29	340	-52.62	0.02	-35.96	7331	3031	7329	6497	2684	0.89
Survey	Oct-08	2.5	-25.99	9.92	-35.96	24799	11278	24754	21944	9970	0.88
Survey	Oct-08	5.64	-35.01	1.04	-35.96	5841	1602	5853	5188	1421	0.89
Survey	Oct-08	14.34	-37.71	0.67	-35.96	9583	4741	9585	8497	4210	0.89
Survey	Oct-08	250	-56.38	0.01	-35.96	2270	1056	2271	2013	-	0.89
					Total	**64148**	-	63878	**56626**	-	-
Eastern Shore											
Fishing	Sep-13	0.4	-27.79	16.49	-35.96	6595	3734	6560	8657	4905	1.31
Mapping	Sep-19	103	-	-	-	16600	-	-	16600	-	-
Fishing	Sep-25	0.25	-21.49	27.99	-35.96	6996	879	7045	9297	1137	1.33
Survey	Oct-03	2.32	-25.66	10.71	-35.96	24855	6062	32645	29653	8874	1.19
					Total	**41455**	-	46250	**46253**	-	-

FIGURES

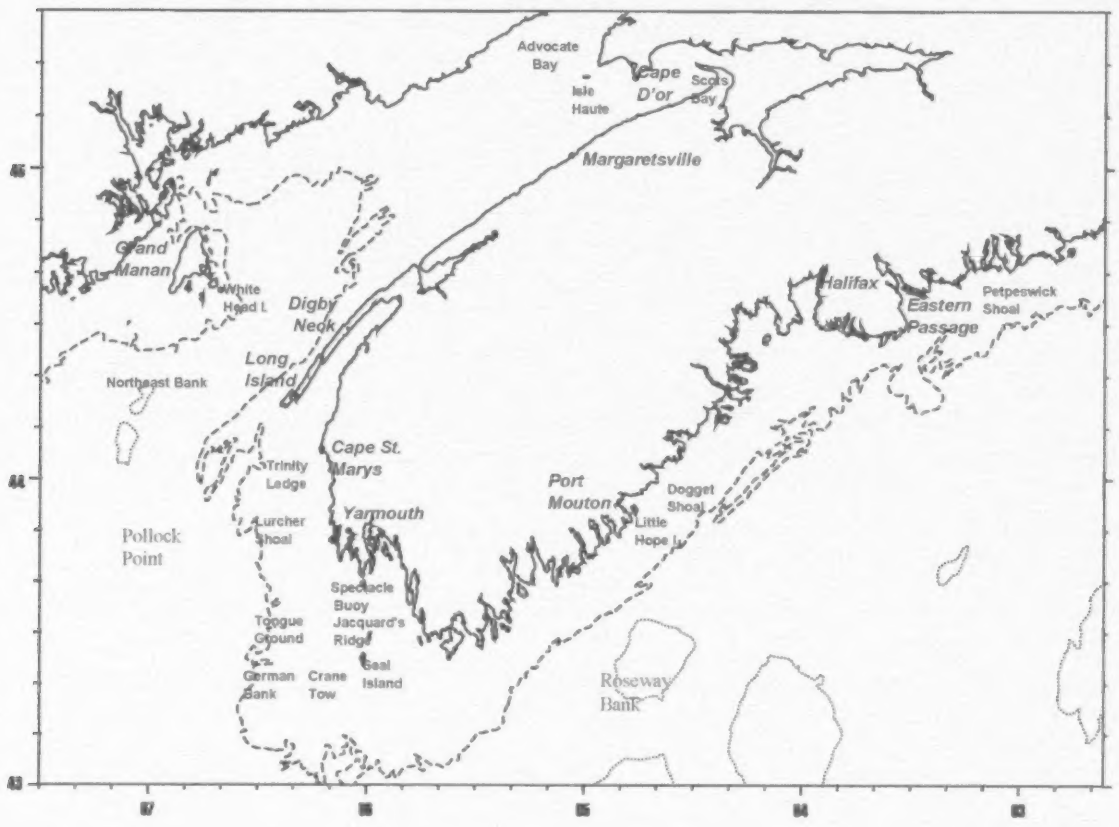

Figure 1. Map of 4WX herring spawning grounds.

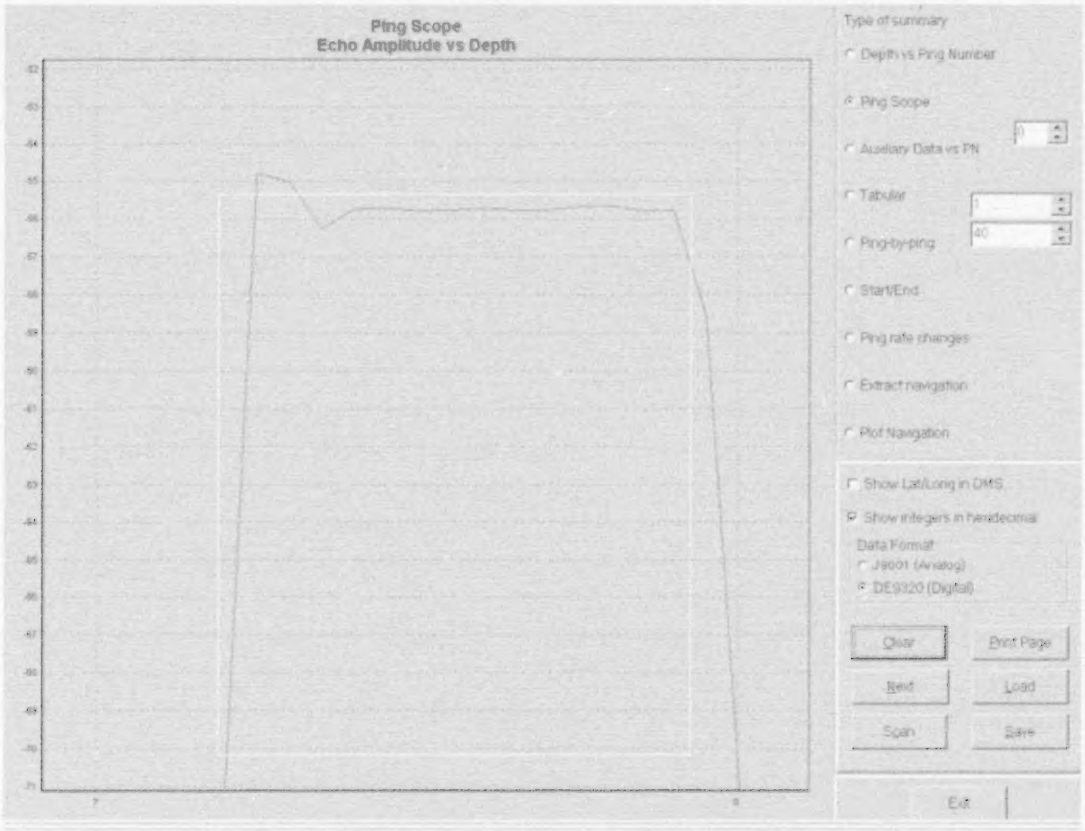

Figure 2. Illustration of an actual measured calibration ball versus an ideal wave form.

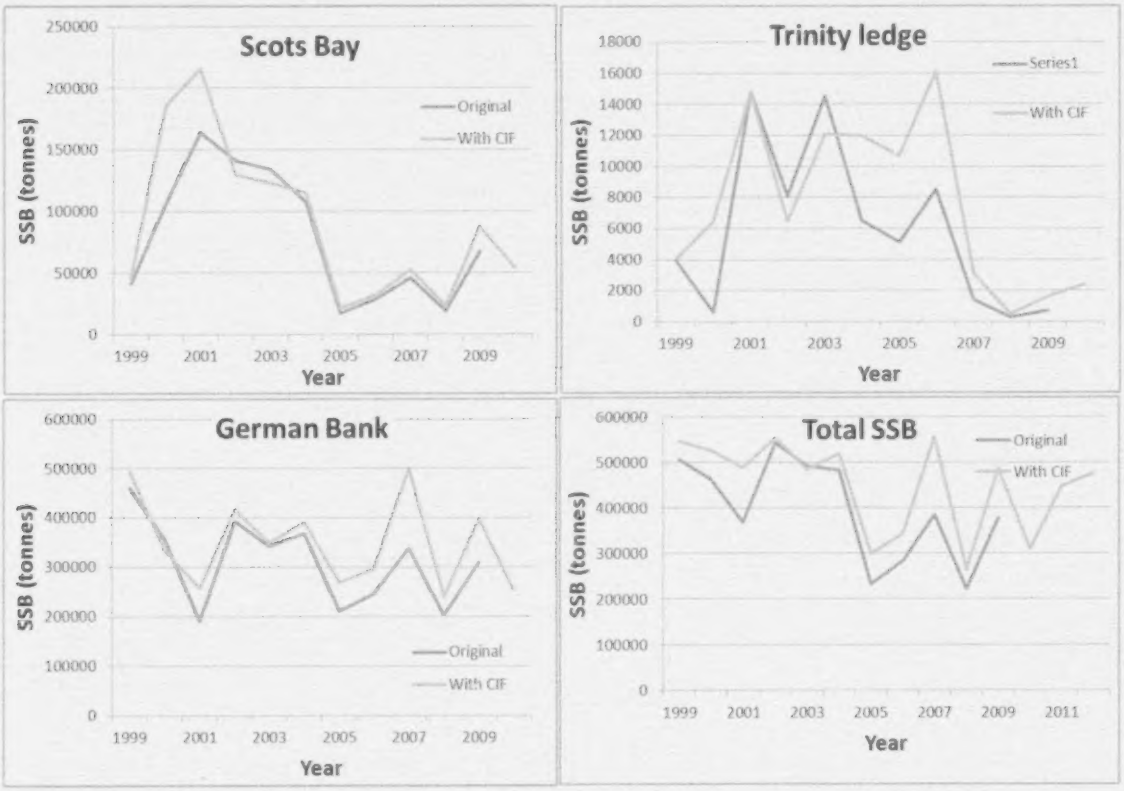

Figure 3. Individual display of the original and the with CIF biomass estimates for German Bank, Trinity Ledge, and Scots Bay, and the total SSB from 1999 to 2012. Note that the without CIF was not calculated after 2009.

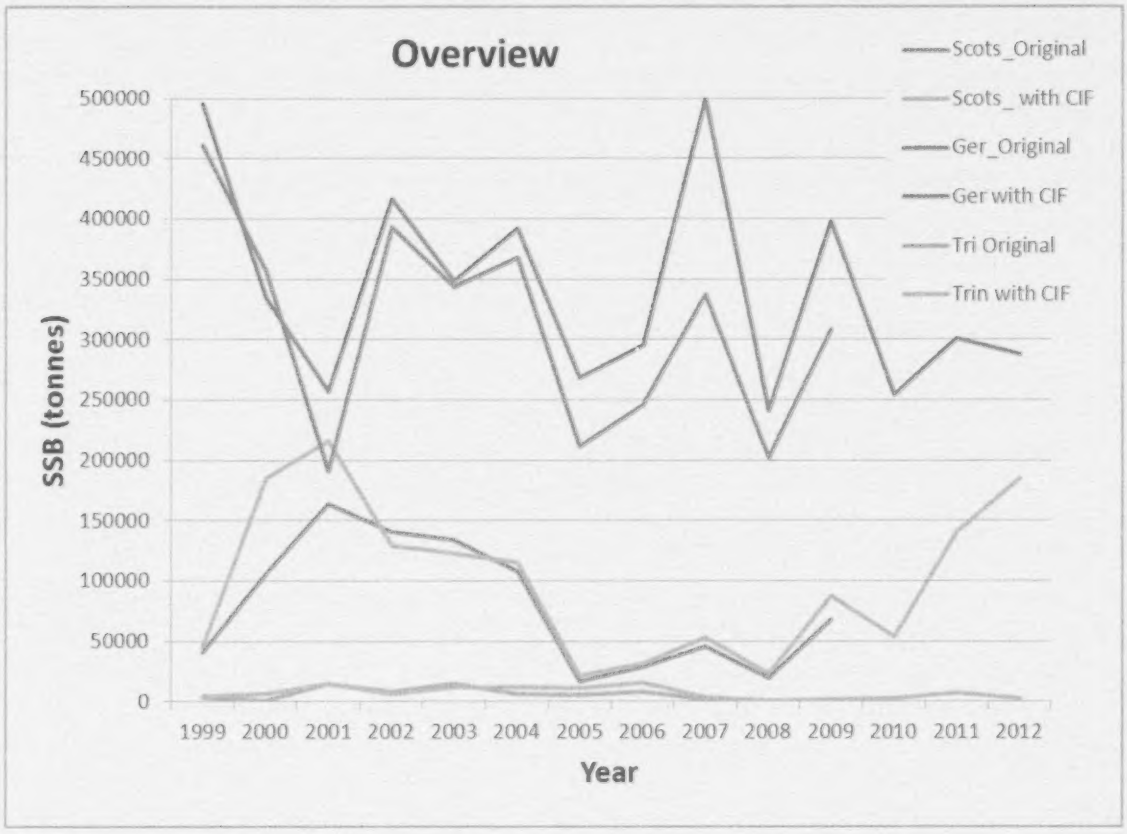

Figure 4. Graphic display of the original and the with CIF biomass estimates for German Bank, Trinity Ledge, and Scots Bay, from 1999-2012. Note that the without CIF was not calculated after 2009.